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STUDIES ON WESTERN AUSTRALIAN PERMIAN BRACHIOPODS 8. THE LATE PERMIAN BRACHIOPOD FAUNA OF THE KIRKBY RANGE MEMBER, CANNING BASIN

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Abstract: The brachiopod fauna of the Late Permian Kirkby Range Member of the Hardman Formation, Canning Basin is described and distinguished from the fauna of the Cherrabun Member of the Hardman Formation. New taxa described are *Waagenites stani* sp. nov. and *Echinalosia (Notolosia) millyiti* sp. nov.

The faunas of both members are retained within the informally named Oppel-zone Stage F of Dickins (1963) as faunas F1 (the Kirkby Range Member fauna) and F2 (the Cherrabun Member fauna). Faunas F1 and F2 are respectively named the *Liveringia magnifica* Zone and the *Waagenoconcha imperfecta* Zone.

The faunas of the Hardman Formation are compared with those of the Upper Marine Beds of the Port Keats Group, Bonaparte Basin and it is concluded that both Hardman faunas have their correlatives in the Bonaparte Basin.

Distinctive Late Permian brachiopod faunas were first recognised from Western Australia by Thomas and Dickins (1954). The faunas were originally collected from beds high in the Liveringa Formation that were assigned to the Hardman Member by Guppy *et al.* (1958). Subsequent mapping (Yeates *et al.* 1975) has discovered two marine horizons within the Hardman Formation as outlined below.

The present study reports on the fauna from the lower marine horizon of the Hardman Formation (that of the Kirkby Range Member). The investigation is based primarily on a sizeable collection of reasonably-well preserved, internal and external moulds collected by Dr S. K. Skwarko (Geological Survey of Western Australia) from a locality on the Western edge of the Millyit Range Plateau, Canning Basin. Comparison is made with collections obtained by Bureau of Mineral Resources field parties and published locality records.

STRATIGRAPHY

The Liveringa Formation was formalised by Guppy *et al.* (1958) who also defined and named two of its three constituent members (specifically the Lightjack and Hardman Members). Subsequent mapping (Yeates *et al.* 1975) resulted in the upgrading of the Liveringa Formation to Group status and the upgrading of its three members to Formation status. The uppermost Hardman Formation was subdivided by Yeates *et al.* (1975) into three members, in ascending order, the Kirkby Range Member, the Hicks Range Sandstone Member and the Cherrabun Member. These members have been widely mapped across the northern Canning Basin (Towner 1977, 1981, Crowe & Towner 1981, Gibson & Crowe 1982). The lower Kirkby Range Member and the upper Cherrabun Member both represent marine incursions while the Hicks Range Sandstone Member represents a non-marine interval. As yet no published studies have attempted to differentiate between the faunas of the two marine members.

FAUNAS, BIOSTRATIGRAPHY AND CORRELATION

It appears clear that previous investigations of Hardman Formation brachiopods have included materials from both marine members. It is now known that the section at Mount Hardman (with a rich series of fossil localities) represents the Cherrabun Member only (Crowe & Towner 1981). Nevertheless many older localities are sufficiently detailed to plot onto the modern maps and more recent collections have invariably been assigned to members. As a result, Table 1 represents a compilation of data in order to discriminate between the two faunas. Some brachiopod species are shared between the two faunas (such as *Neospirifer grandis* and *Tomiopsis hardmani*) and it is not yet clear whether representatives of the Aulostegidae occur in the Kirkby Range Member. All species listed for the Cherrabun Member are known from localities on and around Mount Hardman (in addition, in many cases, to other localities also attributed to the Cherrabun Member) that are documented in the original species descriptions.

Species recorded in the present assemblage from the Kirkby Range Member include *Waagenites stani* sp. nov. (not known elsewhere), *Echinalosia (Notolosia) millyiti* sp. nov., *Streptorhynchus luluigui* and *Liveringia magnifica*. The last species is characteristic of the Kirkby Range Member, being known from such localities as N1241 (see Archbold 1987) and CR 1565 (Lat. 19°4′ Long. 125°8′30″) as well as KNB53 and FL220 (see Archbold 1987), the last two being pre-1970s localities apparently from the Kirkby Range Member. FL220 and KNB53 have also yielded *Streptorhynchus luluigui* (see Thomas 1958a, p. 65), a species not yet found from the Mount Hardman area

TABLE 1
DISTRIBUTION OF BRACHIOPODS IN THE HARDMAN FORMATION

Species	Kirkby Range Member	Cherrabun Member
Streptorhynchus luluigui	✓	–
Streptorhynchus sp. cf. *S. pelargonatus*	–	✓
Derbyia hardmani	–	✓
Neochonetes (*Sommeriella*) sp. nov.	–	✓
Waagenites stani sp. nov.	✓	–
Echinalosia (*Notolosia*) *dickinsi*	–	✓
Echinalosia (*Notolosia*) *millyiti* sp. nov.	✓	–
Liveringia magnifica	✓	–
Aulosteges reclinis	–	✓
Taeniothaerus fletcheri	–	✓
Megasteges fairbridgei	–	✓
Megasteges septentrionalis	–	✓
Waagenoconcha imperfecta	–	✓
Latispirifer amplissimus	–	✓
Neospirifer grandis	✓	✓
Tomiopsis hardmani	✓	✓
Hustedia sp. nov.	–	✓
Cleiothyridina sp.	✓	–
Cleiothyridina penta	–	✓
Cleiothyridina sp. nov.	–	✓
Fletcherithyris hardmani	–	✓
Hoskingia grandis	–	✓

despite extensive collecting, indicating that it is restricted to the Kirkby Range Member. FL220 has also yielded *Neospirifer grandis* and CR1565 has yielded *Tomiopsis hardmani*, both species also being found at Mount Hardman in the Cherrabun Member.

Two features are apparent from Table 1. Firstly, the fauna of the Kirkby Range Member as presently known is rather impoverished when compared with that of the Cherrabun Member. Secondly, despite the impoverished nature of the fauna, a number of species are restricted to the Kirkby Range Member. As a result, it is suggested herein that two faunal assemblages can be distinguished within the Hardman Formation. Hardman Formation faunas have for some time been referred to the informally named Oppel-zone "Stage F" of Dickins (1963). The scheme of Stages outlined by Dickins (1963) has been followed in a recent review (Archbold *et al.* in press) and so the two faunas within the Hardman Formation can be referred to as F1 (The Kirkby Range Member Fauna) and F2 (the Cherrabun Member Fauna). Use of F1 and F2 emphasises the relationships between the two subdivisions. In terms of a more formal zonal scheme, based on brachiopods, the Kirkby Range Member Fauna is named the *Liveringia magnifica* Zone while the Cherrabun Member Fauna is named the *Waagenoconcha imperfecta* Zone. These two Zone species are both common elements of the faunas in which they occur.

Correlation of the Hardman Formation brachiopods has traditionally been with the faunas of the Kalabagh Member of the Wargal Formation and the Chhidru Formation of the Salt Range, Pakistan (Thomas & Dickins 1954, Archbold *et al.* in press). Widespread equivalents of these are known from the Himalayas, Tibet, Timor and elsewhere (Archbold & Thomas 1986b). In terms of the international Permian Timescale, the faunas are generally regarded as being younger than Kazanian and older than Djhulfian. The name Chhidruan is used herein for this intervening time interval for reasons outlined in Archbold *et al.* (in press).

TABLE 2
DISTRIBUTION OF LATE PERMIAN BRACHIOPODS, PORT KEATS AREA

Species	Assemblage C (Localities 5,6)	Assemblage D (Localities 1-4)
Streptorhynchus luluigui	✓	–
Derbya hardmani	–	✓
Waagenites sp.	–	✓
Aulosteges reclinis	✓	✓
Megasteges septentrionalis (=*fairbridgei*)	–	✓
Waagenoconcha imperfecta	–	✓
Costiferina thomasi	–	✓
Leptodus nobilis	–	✓
Neospirifer grandis	✓	✓
Latispirifer amplissimus	–	✓
Tomiopsis hardmani	✓	✓
Cleiothyridina sp. nov.	–	✓
Hustedia sp.	–	✓
Stenoscisma sp.	–	✓
terebratulid indet	–	✓

BONAPARTE BASIN FAUNAS

The presence of Late Permian faunas in the Upper Marine Beds of the Port Keats Group of the Port Keats Region, Bonaparte Basin, Northern Territory was documented by Thomas (1957, 1958b) who correlated them with "the fauna of the Hardman Member of the Liveringa Formation". Thomas (1957) listed two assemblages which he regarded as being transitional although he noted (1958b, p. 3) that his assemblage D was stratigraphically higher than assemblage C. Collections made by Thomas have been reviewed and are summarized in Table 2. Localities are those numbered by Thomas (1957, p. 176).

The two assemblages in the Port Keats Area match closely those of the Hardman Formation with some specific variation. *Waagenites* sp. (from Thomas' Locality 4) is not conspecific with *Waagenites stani* sp. nov. which is a larger species with coarser costae. *Liveringia magnifica* is not known from the Port Keats Area. Members of the Aulostegidae are known from both Port Keats assemblages indicating their likely presence in both Hardman Formation assemblages. Some additional elements, such as *Leptodus nobilis*, are known from Assemblage D which are not known from the Cherrabun Member.

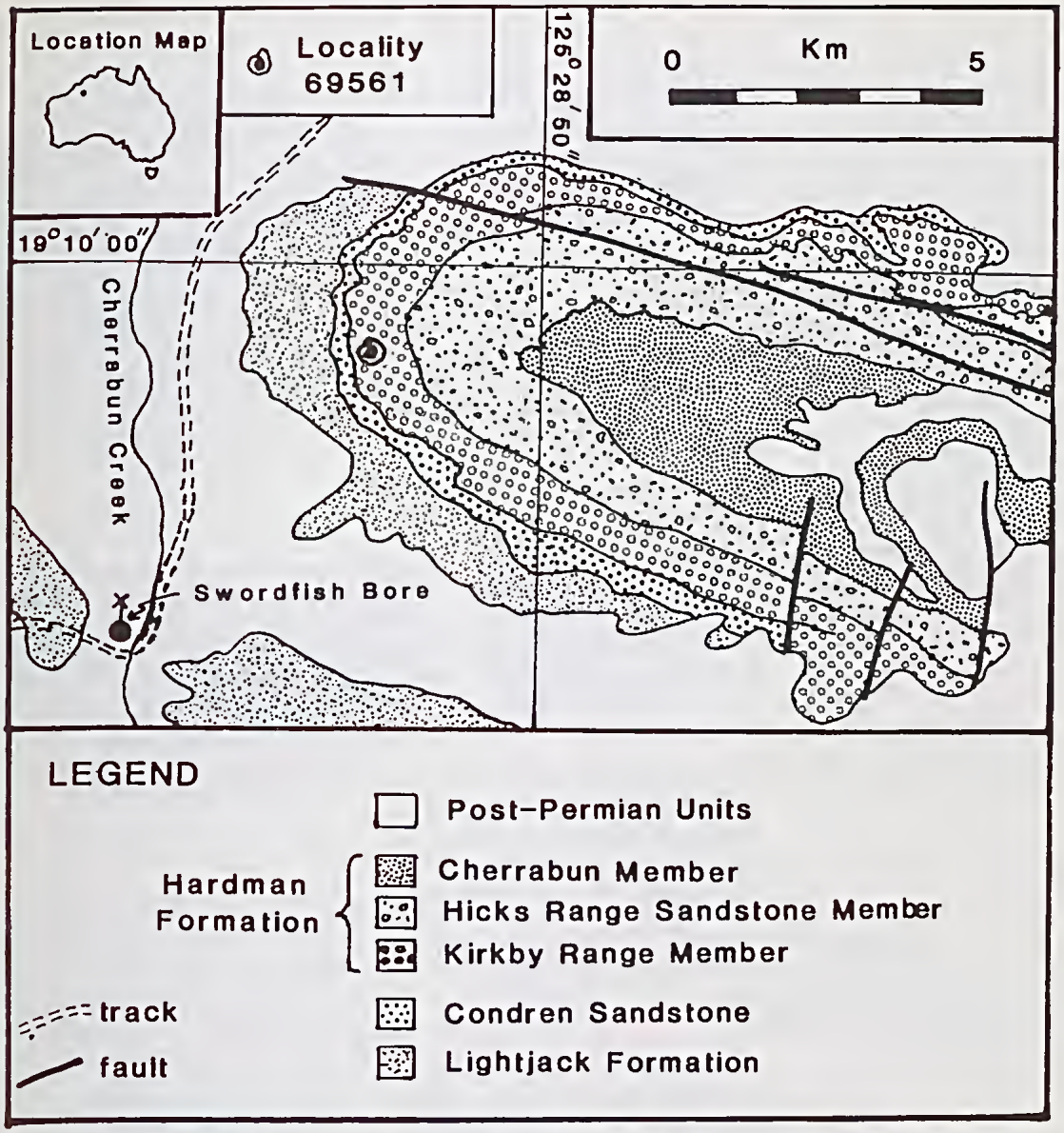


Fig. 1—Location Map, Millyit Range, Canning Basin, Western Australia.

COLLECTIONS

The collection from the Kirkby Range Member described herein was made by Dr S. K. Skwarko (Geological Survey of Western Australia), in June 1985, from GSWA locality 69561 (Photo reference, Crossland Run 3, Photo 5029). The locality is on the western rim of the Millyit Range Plateau, about 6 km north east of Swordfish Bore (Fig. 1).

All specimens are preserved as internal or external moulds (often ferruginous and hence with fine detail preserved) in a buff coloured, at times friable, micaceous, silty sandstone. Latex casts have been made from the moulds and these reveal the fine detail of the specimens.

Specimens are registered with the Geological Survey of Western Australia (GSWA), Perth and the Commonwealth Palaeontological Collections (CPC) of the Bureau of Mineral Resources, Geology and Geophysics, Canberra.

All figured specimens of new species, other than holotypes are paratypes.

SYSTEMATIC PALAEONTOLOGY

Order Strophomenida Öpik, 1934
Suborder Orthotetidina Waagen, 1884
Superfamily Orthotetacea Waagen, 1884
Family Streptorhynchidae Stehli, 1954

Genus **Streptorhynchus** King, 1850

Type Species: *Terebratulites pelargonatus* Schlotheim 1816.

DIAGNOSIS: Streptorhynchidae with non-plicate shells, maximum width greater than hinge width, dental plates low; dorsal valve convex, cardinal process bilobed, sockets deep, socket plates not recurved.

DISCUSSION: The genus has been fully discussed by Thomas (1958a) and distinctions between *Streptorhynchus* and other genera such as *Arctitreta* and *Grumantia* have been summarised by Waterhouse (1982a).

Streptorhynchus luluigui Hosking 1932
Fig. 2A-Q

1932 *Streptorhynchus luluigui* Hosking, p. 45; pl. 4, figs 1-7; pl. 5, figs 1-4.
1937 *Streptorhynchus luluigui* Hosking, Clarke, p. 428.
1957 *Streptorhynchus* c.f. *luluigui* Hosking, Thomas, p. 181.
1958a *Streptorhynchus luluigui* Hosking, Thomas, p. 62; pl. 8, figs 9-10; pl. 17, figs 1-5; pl. 19, figs 3, 6; text fig. 11c.
1958b *Streptorhynchus* aff. *S. luluigui* Hosking, Thomas p. 3.
1958 *Streptorhynchus luluigui* Hosking, Guppy *et al.* p. 54.
1969 *Streptorhynchus luluigui* Hosking, Thomas, p. 221.

LECTOTYPE: Specimen UWA 3040L, from near Luluigui Homestead, selected by Thomas (1958a, p. 62).

COMMENTS: This species has been well described by Hosking (1932) and Thomas (1958a). It is a distinctive, large species for the genus. The present suite of specimens conforms well to the range of morphological variability recorded for the species by Thomas (1958a). A range of specimens is figured herein (Fig. 2) to illustrate the variation of the present population and a complete synonymy is provided for the species.

Order PRODUCTIDA Sarycheva and Sokolskaya, 1959
Suborder CHONETIDINA Muir-Wood, 1955
Superfamily CHONETACEA Bronn, 1862
Family RUGOSOCHONETIDAE Muir-Wood, 1962
Subfamily RUGOSOCHONETINAE Muir-Wood, 1962

Genus **Waagenites** Paeckelmann 1930
= **Dienerella** Reed 1931

TYPE SPECIES: *Chonetes grandicosta* Waagen, 1884.

DIAGNOSIS: Small, subquadrate rugosochonetids with uniplicate commissure, coarse costae and narrow, often deep ventral sulcus. Ventral valve strongly convex. Dorsal valve weakly to strongly concavely

DISCUSSION: Questions remain as to the nature and variation of the dorsal internal structures of the type species as discussed by Archbold (1983a, p. 71). The short dorsal median septum, developed only near the valve centre as indicated by Muir-Wood (1962) and Grant (1976), may not always be a feature of mature *Waagenites*. In a well-illustrated study of specimens of *Waagenites* from Western Yunnan (Fang 1983) smaller specimens possess the short, centrally-located, median septum (Fang 1983, pl. 2, figs 8, 14) whereas a larger specimen has a distinct median septum, arising anteriorly of a deep alveolus, and distinct lateral septa. This latter arrangement, close to that of *Neochonetes* and other rugosochonetids, is also shown by *Waagenites stani* sp. nov. as described herein and reinforces the rugosochonetid affinity of *Waagenites*.

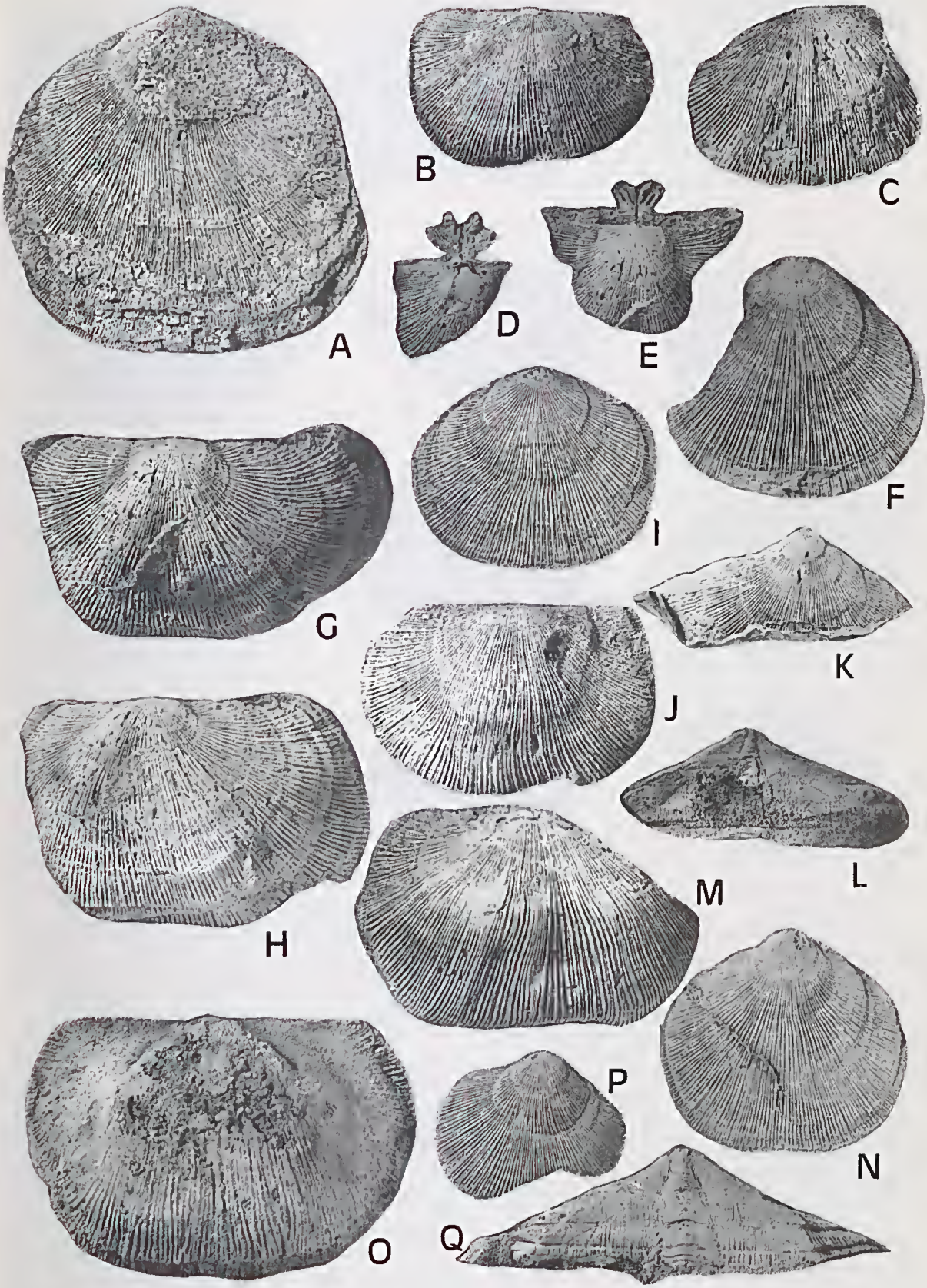
In a previous discussion of *Waagenites* (Archbold 1982c), emphasis was placed on the generic importance of a deep ventral sulcus. The study by Fang (1983) would indicate that less emphasis should be placed on this feature (although a narrow sulcus is always present). This would then permit Late Permian records of coarsely costate chonetids with shallow sulci from China, Japan and the Soviet Far East to be retained within *Waagenites* contrary to Archbold (1982c, p. 6).

Waagenites, despite a poorly-known, Early Permian history, apparently starting in the Sakmarian (Mirskaya *et al.* 1956), became a highly successful Late Permian genus throughout the Tethys. It is characteristic of Late Permian faunas of the Cimmerian Province of Gondwana (Archbold 1982c, 1983a) including much of Tibet (Jin 1985) and Western Yunnan (Fang 1983). It persisted into the Latest Permian tropical faunas of China (Liao 1980), penetrated the northern subtropical faunas of Japan and the Soviet Far East (Tazawa 1976, Likharev & Kotlyar 1978) and is now described from the Late Permian subtropical faunas of the Westralian Province of Gondwana.

Waagenites stani sp. nov.
Fig. 3A-L

ETYMOLOGY: For Dr S. K. Skwarko, collector of the species.

Fig. 2—A-Q, *Streptorhynchus luluigui* Hosking. All from GSWA locality 69561. A, GSWA F11208, latex cast of ventral valve in ventral view, x 1.2 B, GSWA F11209, latex cast of juvenile dorsal valve exterior, x 1.2. C, GSWA F11210, latex cast of dorsal valve exterior, x 1.2. D, GSWA F11211, latex cast of portion of dorsal valve exterior, x 1. E, GSWA F11212, latex cast of portion of dorsal valve exterior, x 1. F, GSWA F11213, latex cast of submature ventral valve exterior, x 1.2. G-H, GSWA F11214, latex cast of ventral valve exterior in posterior and ventral views, x 1.2 and x 1. I, GSWA F11214, latex cast of juvenile ventral valve exterior, x 1.2. J, GSWA F11216, latex cast of dorsal valve exterior, x 1.2, note damage during juvenile growth stage. K-L, GSWA F11217, latex cast of posterior of ventral valve in ventral and dorsal views, x 1. M, GSWA F11218, latex cast of incomplete dorsal valve exterior, x 1.1. N, GSWA F11219, latex cast of juvenile ventral valve exterior, x 1.3. O, GSWA F11220, dorsal valve internal mould in dorsal view, x 1.2. P, GSWA F11221, latex cast of juvenile ventral valve exterior, x 1. Q, GSWA F11222, latex cast of ventral valve interarea, x 1.5.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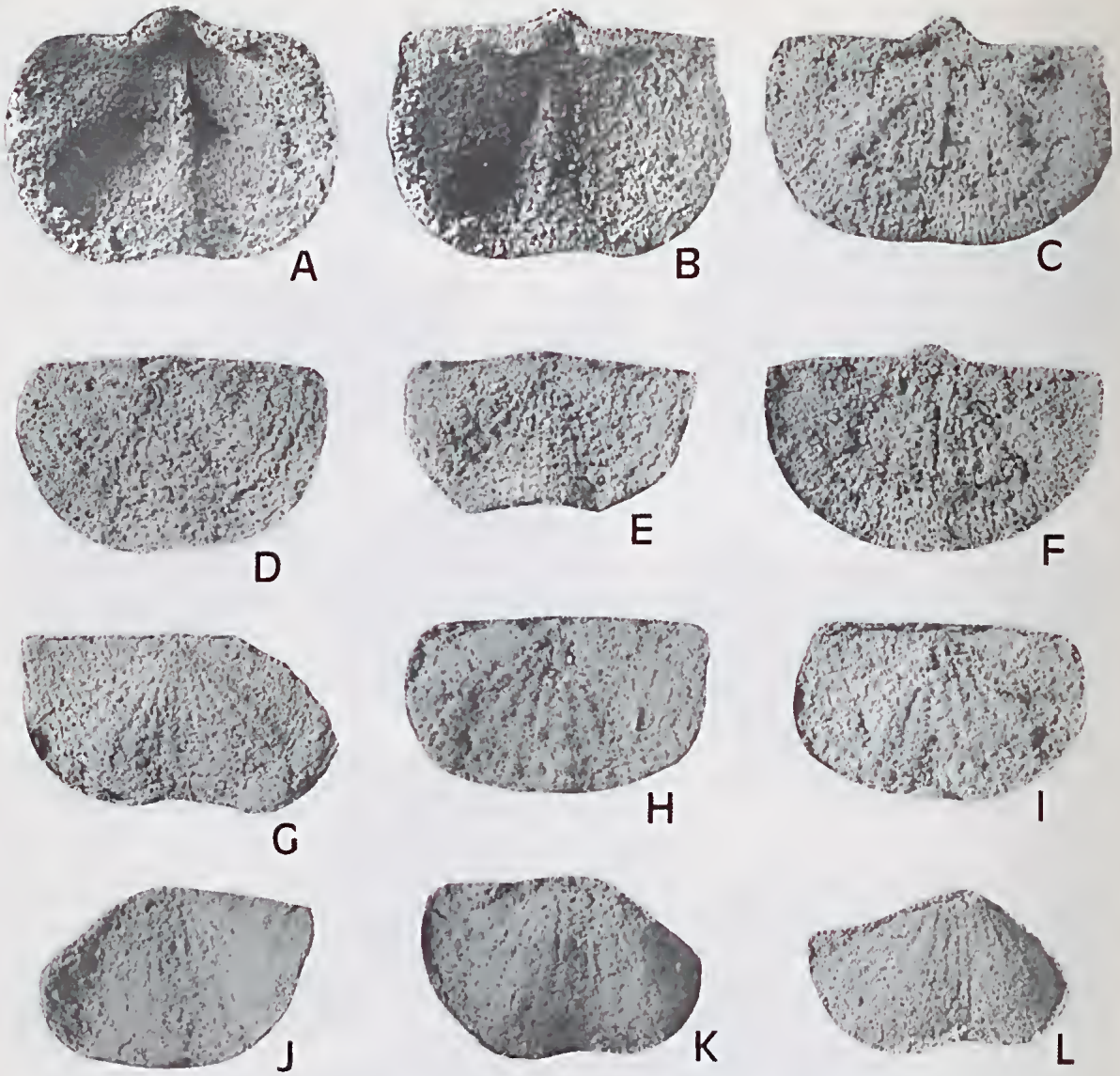


Fig. 3—A-L, *Waagenites stani* sp. nov. All from GSWA locality 69561. A, GSWA F11230, latex cast from ventral valve internal mould, x 5. B, GSWA F11231, Latex cast from ventral valve internal mould, x 5. C, F, GSWA F11227, latex cast of dorsal valve internal mould of dorsal valve, x 5. D, GSWA F11224, latex cast of dorsal valve external mould, x 4.5. E, GSWA F11225, latex cast of dorsal valve external mould, x 5.5. G, GSWA F11223, holotype, dorsal valve external mould, x 5. H-I, GSWA F11226, latex cast of dorsal valve and external mould of dorsal valve, x 5.5. J-K, GSWA F11228, external mould of ventral valve and latex cast from mould, x 5.5. L, GSWA F11229, latex cast from ventral valve external mould, x 5.

Holotype: GSWA F11223, an external mould of a dorsal valve.

Material: GSWA F11223-11231, 4 dorsal valve, external moulds; 1 dorsal valve, internal mould; 2 incomplete ventral valve, external moulds; and, 2 ventral valve, internal moulds, all from GSWA locality 69561.

Size Ranges: Hinge width, 6.5-8.9 mm; maximum width, 7.3-9.5 mm; ventral valve height, 7.1-7.8 mm; dorsal valve height, 4.7-6.1 mm.

Diagnosis: Small, subquadrate shells with coarse costae, deeply-convex ventral valve with shallow sulcus, feebly-concave dorsal valve with low median fold.

Description: Shells small, transverse, subquadrate in outline with deeply-convex ventral valve and feebly-concave dorsal valve. Ventral umbo low, inconspicuous. Cardinal extremities rounded. Ventral interarea distinct, bisected by relatively large delthyrium. Ventral exterior with coarse costae, increasing by

branching, on valve flanks and in sulcus; concentric growth lamellae indistinct. Sulcus narrow, broadens towards commissure, remains shallow.

Ventral teeth relatively large, blunt. Ventral median septum distinct, coarse, arises under delthyrium, extends forward for some two-thirds of valve length. Muscle scars and pustules not visible.

Dorsal valve with low median fold, broadening anteriorly. External ornament of distinct growth lamellae and coarse costae increasing by branching. Cardinal process wide, blunt, posterior of relatively large, deep alveolus. Socket ridges distinct. Median septum arises anteriorly of alveolus and continues forward for half of valve length as distinct, fine structure. Short lateral septa, arising close to origin of median septum, distinct. Brachial ridges broad, low. Anterior of valve interior with radiating rows of pustules.

Discussion: *Waagenites stani* sp. nov., the first described species of the genus from the Australian continent, is known from only one locality and on the basis of a small collection preserved in an unfavourable matrix. Nevertheless, despite the fact that the genus has been widely recorded from elsewhere for many years, most species are known only from ventral valves. *Waagenites yunnanensis* Fang (1983, pl. 1, figs 12a-g; pl. 2, figs 1-3) is perhaps closest to the new species, possessing a comparable dorsal interior at maturity, but with a shorter ventral median septum and well-demarcated, ventral, vascular trunks. Other species described by Fang (1983) are often based on smaller specimens that may be juvenile or submature specimens. The age of the Yunnan species is comparable with that of *Waagenites stani* sp. nov.

A single specimen attributable to *Waagenites* is known from assemblage D of the Upper Marine Beds, Port Keats Group, Northern Territory. The specimen comprises both the external and internal moulds of a small ventral valve and possesses a deeper sulcus and shorter, posteriorly-located, median septum than *Waagenites stani* sp. nov.

Suborder Strophalosiidina Waterhouse, 1975
Superfamily Strophalosiacea Schuchert, 1913
Family Strophalosiidae Schuchert, 1913
Subfamily Strophalosiinae Schuchert, 1913

Genus **Echinalosia** Waterhouse, 1967
Subgenus **Echinalosia (Notolosia)** Archbold, 1986

Type Species: *Echinalosia (Notolosia) dickinsi* Archbold, 1986.

Discussion: The genus and subgenus have been diagnosed and discussed by Archbold (1986). When describing the type species, Archbold (1986, p. 116) referred several large natural casts of ventral valves with coarse anterior spines to it, attributing the coarseness of the spines to the nature of the preservation. New material from locality 69561 indicates the presence of a species with relatively coarse ventral spines in the Kirkby Range Member which is referred to *Echinalosia (Notolosia)*. The natural casts previously figured by me (1986, Fig. 6I-N), also from the Kirkby Range Member, are now referred to the new species *Echinalosia (Notolosia) millyiti*.

Echinalosia (Notolosia) millyiti sp. nov.
Fig. 4A-M

1986 *Echinalosia (Notolosia) dickinsi* Archbold, (*partim*), p. 116, fig. 6I-N, (*non cet.*).

Etymology: From the Millyit Range, Canning Basin.

Holotype: GSWA F11232, a ventral valve, external mould with counterpart internal mould also preserved.

Material and Localities: CPS 24468-24472, five natural casts of ventral valves from BMR locality N1241, Lat. 19°06′38″S, Long. 129°11′27″E, Kirkby Range Member, Hardman Formation. CPC 19144, a natural cast of a dorsal valve, same locality and horizon. GSWA F11232-11236, 4 ventral valve, external moulds (GSWA F11232 also with internal mould) and 1 dorsal valve, external mould from GSWA locality 69561.

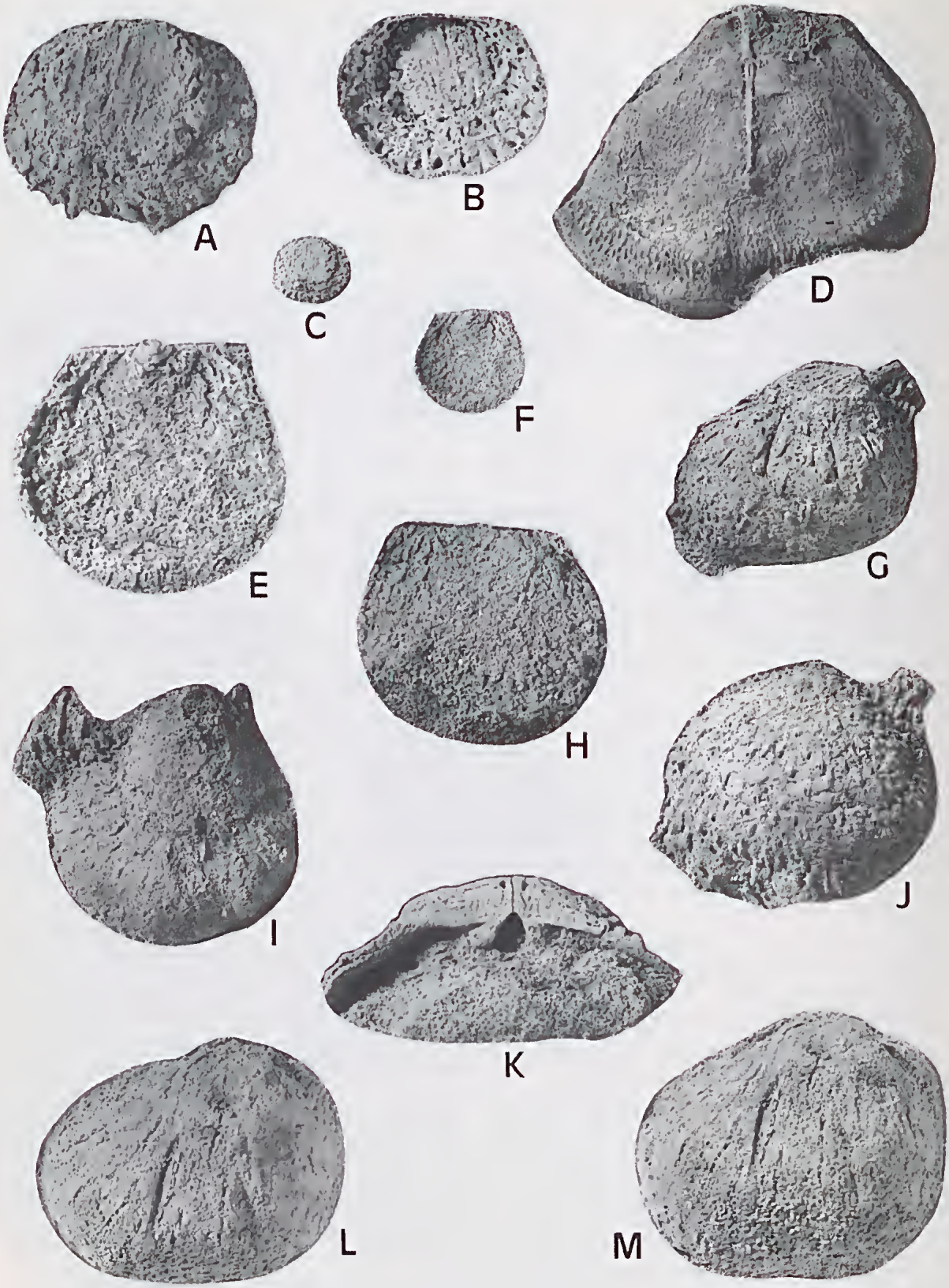
Size Ranges: Hinge width, 5.5-15.5 mm; maximum width, 10.4-26.5 mm; ventral valve height, 9.3-22.5 mm; dorsal valve height, 12.8-20.0 mm; shell thickness, 7.5-12.1 mm; ventral interarea height, 2.3-2.5 mm.

Diagnosis: Medium-sized shells with narrow hinge and transversely-oval outline in maturity. Cicatrix large and prominent. Ventral ornament of concentric lamellae and medium to coarse, scattered to subconcentrically-arranged, spines. Spines clustered on posterior valve margins recumbent near cicatrix. Dorsal exterior with scattered dimples, concentric lamellae and traces of minute spines.

Description: Medium-sized shells, transversely oval at maturity. Hinge width varies from one half to three fifths maximum width. Hinge extremities rounded throughout ontogeny. Ears not developed. Ventral valve strongly convex. Maximum width at about two-thirds of length of shell from umbo at maturity. Umbo flattened by cicatrix of attachment which is large, prominent and reflects the initial object of attachment (two specimens reflect the ribbing of a shell—to judge from the rib size probably *Streptorhynchus luluigui*).

Ornamentation of ventral valve consists of concentric lamellae (best developed on valve anterior at maturity) and spines. Spines scattered over valve subconcentrically, relatively coarse (up to 0.7 mm thick on anterior of holotype, approach 1.0 mm in thickness on anterior of larger specimens), and spaced at 1 to 2.5 mm intervals over venter. Spines more closely spaced over posterior lateral flanks (either side of large cicatrix) and long (up to 6 mm long on GSWAF 11234). Spines close to cicatrix, at times adherent to shell.

Interareas distinct, flat, extend full width of shell. Ventral interarea high, striated parallel to hinge, bisected by narrow, triangular delthyrium with flat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pseudodeltidium with anterior V-shaped notch. Dorsal interarea low, poorly known.

Dorsal valve gently convex initially (corresponding to initial flat cicatrix), becomes gently concave subsequently with anterior gentle geniculation. Concentric lamellae present. Dimples coarse, scattered over valve exterior. Fine dorsal spines present (minute, 0.1 mm thick on GSWAF 11236 which only retains traces of 4 or 5 spines on lateral margin probably because of relatively coarse matrix).

Ventral teeth small, weakly divergent, protrude at same level as interarea. No marginal ridge developed. Adductor scars situated on region of cicatrix, smooth. Diductor scars large, coarsely striate. Anterior of valve interior pitted and striate.

Cardinal process unknown. Dorsal median septum prominent, bisects adductor scars which are smooth and not differentiated. Region of brachial ridges smooth resulting in demarcation of brachial ridges. Anterior of valve strongly pustulose.

Discussion: The new species is referred to *Echinalosia (Notolosia)* on the basis of its consistently-large cicatrix of attachment and the nature of its exterior ornament. Better-preserved, dorsal exteriors would confirm the details of dorsal spinosity. The coarser ventral spines and larger size of the species serve to differentiate the species from *E. (N) dickinsi* Archbold (1986) which also is characterized by more closely-spaced ventral spines (now being based exclusively on Mount Hardman, Cherrabun Member specimens).

No other species are known with certainty to fall within the concept of *Echinalosia (Notolosia)* however *Echinalosia minuta* (Ching in Chang & Ching 1976, p. 168, pl. 1, figs 25-27 and text fig. 4) could be allied judging from its coarse ventral spines and its possible large cicatrix of attachment (subject to interpretation of Ching's text fig. 4). The *Strophalosia indica* of Waagen (1884, p. 648, pl. 65, figs 1-4) may also be allied as several specimens possess a cicatrix of reasonable size (Waagen 1884, pl. 65, figs 2b, 2c, 1e, 1c).

Genus **Liveringia** Archbold 1987

Type Species: *Liveringia magnifica* Archbold 1987.

Discussion: This distinctive genus is only known from Western Australia by its type species. In general terms the genus shares features with *Wyndhamia* Booker (1929) and the species described as *Wyndhamia circularis* Chang (in Chang & Ching 1976, p. 166, pl. 2, figs 1-15; see also Jin 1985, p. 58, pl. 2, figs 2-3, 6, 9, 12) but is distinguished from those by details of external ornament as discussed by Archbold (1987).

The *Aulosteges* sp. of Yang and Zhang (1982, p. 312, pl. 1, figs 2-4) represents additional illustrations of *Wyndhamia circularis* Chang.

Liveringia magnifica Archbold 1987
Fig. 5A-J

1987 *Liveringia magnifica* Archbold, p. 32; figs 6A-L, 7A-L

Holotype: Specimen CPC 26450, from near mouth of Nerrima Creek, Canning Basin, apparently Kirkby Range Member.

Comments: The present suite of specimens extends the range of size from the previous description but offers no new morphological information. A range of specimens is figured herein to illustrate the variation of the present population.

Order Athyridida Dagys, 1974
Suborder Athyridina Boucot, Johnson & Staton, 1964
Superfamily Athyridacea M'Coy, 1844
Family Athyrididae M'Coy, 1844
Subfamily Athyridinae M'Coy, 1844

Genus **Cleiothyridina** Buckman, 1906

Type Species: *Atrypa pectinifera* Sowerby 1840.

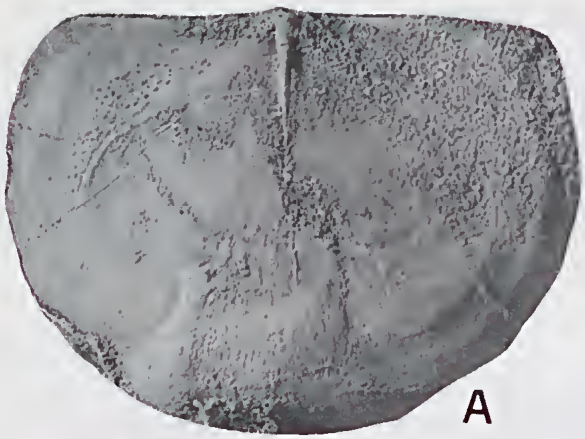
Diagnosis: Weakly-folded Athyridinae with small foraman. Growth lamellae closely spaced with raised edges and short, flat, uniramous spines. Ventral valve with dental plates; dorsal valve with perforated hinge plate.

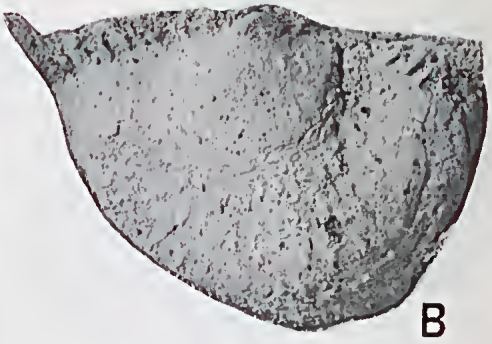
Discussion: The present material (a single dorsal valve internal mould and a poor internal mould of a conjoined shell) adds nothing to the generic understanding. It is compared with the species *Cleiothyridina penta* Prendergast (1935) which may be better assigned to *Pinegathyris* Grunt (1980). That species will be described fully elsewhere in a study on Western Australian Permian athyrids by Dr G. A. Thomas and myself.

Cleiothyridina sp.
Fig. 6A-C

Comments: A large species of *Cleiothyridina* s.l. is represented in the present collections by an internal mould of a dorsal valve and an internal mould of a shell. A distinct dorsal fold is present and a low fastigium with a corresponding shallow ventral sulcus. The ventral muscle field is large and deeply impressed and the dorsal median septum is distinct.

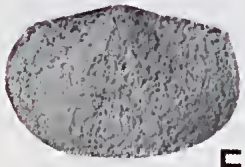
Fig. 4—A-M, *Echinalosia* (*Notolosia*) *millyiti* sp. nov. A-C, E-J, L-M, all from GSWA locality 69561; D, K, from BMR locality N1241. A-C, GSWA F11233, latex cast of ventral valve exterior, external mould of ventral valve and the latex cast, x 4.5, x 3.5, x 1. D, CPC 19144, natural cast of dorsal valve interior, x 3. E, F, H, GSWA F11236, latex cast of dorsal valve external mould, x 3.5 and x 1 and dorsal valve external mould, x 2.5. G, L-M, GSWA F11232, holotype, latex cast of ventral valve external mould and internal mould of ventral valve in postero-ventral and ventral views, x 2.2, x 3 and x 3. 1, GSWA F11234, latex cast of ventral valve external mould, x 2.2. J, GSWA F11235, latex cast of ventral valve external mould, x 2.2. K, CPC 24468, natural cast of ventral valve showing ventral interarea, x 3.


A


B


C


D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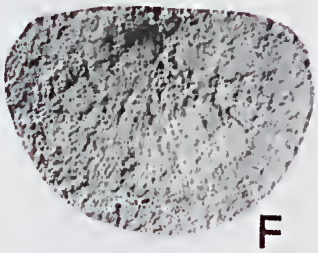
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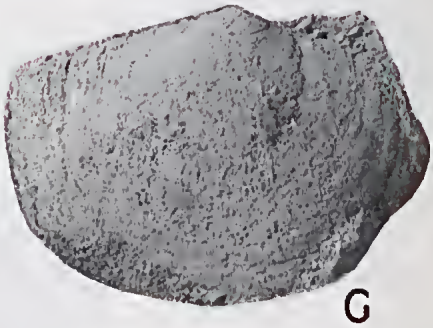
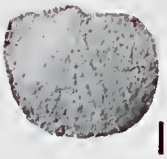

G


H


I


J

Fig. 6—A-C, *Cleiothyridina* sp. All from GSWA locality 69561. A, GSWA F11245, internal mould of dorsal valve, x 1.2. B-C, GSWA F11246, internal mould of shell in ventral and dorsal views, x 1.

Preservation of neither specimen permits close comparison with other species but details of the gross morphology suggest a relationship with *Cleiothyridina penta* Prendergast (1935), an apparently smaller species from the Cherrabun Member that may also be assigned to *Pinegathyris*. Prendergast's species had previously been referred by Chapman (1924a, 1924b, 1925), Glaucrt (1926, p. 47) and Blatchford (1927, p. 19) to such European Carboniferous species as "*Athyris*" *roysii* and "*Athyris*" *lamellosa*.

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REFERENCES

References are supplementary to those in Part 1-7 (*Proc. R. Soc. Vict.* Vol. 91, p. 181; vol. 93, p. 109; vol. 95, p. 237; vol. 96, p. 83; vol. 97, p. 19; vol. 98, p. 97; vol. 99, p. 19).

Archbold, N. W., 1982e. Classifieation and evolution of the brachiopod family Rugosochonetidae Muir-Wood 1962. *Proc. R. Soc. Vict.* 94: 1-9.

Archbold, N. W., Studies on Western Australian Permian brachiopods. 7. The strophalosiid genera *Wyndhamia* Booker, 1929, *Lialosia* Muir-Wood and Cooper, 1960 and *Liveringia* gen. nov. *Proc. R. Soc. Vict.* 99: 19-35.

Archbold, N. W., Dickins, J. M. & Thomas, G. A., in press. Correlation and age of the Western Australian marine faunas. In *Permian Palaeontology of Western Australia*, Skwarko, S. K., ed., Bull. Geol. Surv. W. Aust.

Blatchford, T., 1927. The geology of portions of the Kimberley Division, with special reference to the Fitzroy Basin and the possibilities of the occurrence of mineral oil. *Bull. Geol. Surv. W. Aust.* 93: 1-56.

Buckman, S. S., 1906. Brachiopod nomenclature. *Ann. Mag. Nat. Hist.* Ser. 7, 18: 321-327.

Boucot, A. J., Johnson, J. G. & Staton, R. D., 1964. On some atrypoid, retzioid and athyridoid Brachiopoda. *J. Paleont.* 38: 805-822.

Clarke, E. deC., 1937. Correlation of the Carboniferous and Permian formations of Australia, 11 Western Australia. *Rep. Aust. N.Z. Assoc. Advmt Sci.* 23: 427-430.

Crowe, R. W. A. & Towner, R. R., 1981. 1:250000 Geological Series Explanatory Notes. *Noonkanbah* Western Australia Sheet SE/51-12 International Index. Aust. Gov't Publ. Service Canberra. 51 pp.

Dagys, A. S. 1974. Triasovye brakhiopody (morfologya, sistema, filogenya, stratigraficheskoe znachenie i biostratigrafiya). *Akad. Nauk SSSR, Sib. Otdel., Inta Geol. Geofiz., Trudy* 214: 1-387.

Dickins, J. M., 1963. Permian pelecypods and gastropods from Western Australia. *Bull. Bur. Mincr. Resour. Geol. Gcophys Aust.* 63: 1-203.

Fang, R.-S., 1983. The Early Permian Brachiopoda from Xiaoxinzhai of Gengma Yunnan and its geological significance. *Contrib. Geol. Qinghai-Xizang (Tibet) Platcau* 11: 93-119.

Gibson, D. L. & Crowe, R. W. A., 1982. 1:250000 Geological Series—Explanatory Notes. *Mount Anderson* (Second Edition) Western Australia. Sheet SE/51-11 International Index. Aust. Gov't. Publ. Service. Canberra. 44 pp.

Grunt, T. A., 1980. Atiridídy Russkoi Platformy. *Akad. Nauk SSSR, Trudy Paleont. Inst.* 182: 1-164.

Fig. 5—A-J, *Liveringia magnifica* Archbold. A, from BMR locality CR1565; B-J, from GSWA locality 69561. A, CPC 19850, natural cast of a dorsal valve showing details of brachial ridges, x 1.6. B, GSWA F11237, latex cast of ventral valve external mould, x 2.5. C, GSWA F11238, natural worn cast of a gerontic ventral valve, x 1.1. D, GSWA F11239, external mould of gerontic dorsal valve, x 1. E, GSWA F11240, latex east of external mould of worn juvenile ventral valve, x 1.5. F, GSWA F11241, internal mould of juvenile dorsal valve, x 3. G, GSWA F11242, latex cast of external mould of worn ventral valve, x 1.5. H, GSWA F11243, natural cast of juvenile ventral valve, x 2.8. I-J, GSWA F11244, latex cast of mould of juvenile ventral valve exterior, x 1 and x 2.5.

HOSKING, L. F. V., 1932. Western Australian Orthotetinae. *J. R. Soc. W. Aust.* 18: 43-53.

LIAO, Z-T., 1980. Brachiopod assemblages from the Upper Permian and Permo-Triassic boundary beds, South China. *Can. J. Earth Sci.* 17: 289-295.

LIKHAREV, B. K. & KOTLYAR, G. V., 1978. Permskie brakhiopody Yuzhnogo Primor'ya. In *Verkhniy Paleozoy Severo-Vostochnoy Asii*. Akad Nauk SSSR, Dalnev. Nauch. Tsentr, Inst. Tektoniki i Geofiziki. Vladivostok. pp. 63-75, 96-99.

M'COY, F. 1844. *A Synopsis of the Characters of the Carboniferous Limestone Fossils of Ireland*. Dublin University Press. 207 p.

ÖPIK, A. A. 1934. Über Klitamboniten. *Acta & Commentationes, Tartu Univ.* Ser. A. 26(5): 1-239.

REED, F. R. C., 1931. New fossils from the Productus Limestone of the Salt Range with notes on other species. *Mem. geol. Surv. India, Palaeont Indica* N.S. 17: 1-56.

SCHLOTHEIM, E. F. VON, 1816. Beytrage zu Naturgeschichte der versteinerungen in geognostischer hinsicht. *Denkschrift. K. Akad. Wiss. Munchen, math.-phys. Klasse* 6: 13-36.

SOWERBY, J. DEC., 1840. The Mineral Conchology of Great Britain. 7: 1-80. London.

TAZAWA, J., 1976. The Permian of Kesennuma, Kitakami Mountains: A preliminary report. *Earth Science (Chikyu Kagaku)* 30(3): 175-185.

THOMAS, G. A., 1985a. The Permian Orthotetacea of Western Australia. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* 39: 1-159.

THOMAS, G. A., 1958b. Stratigraphy and palaeontology of the Port Keats Area, Northern Territory. *ANZAAS, Adelaide Congress, Section C, Abstracts Lectures, Papers,* p. 1-5.

THOMAS, G. A. & DICKINS, J. M., 1954. Correlation and age of the marine Permian formations of Western Australia. *Aust. J. Sci.* 16: 219-223.

TOWNER, R. R., 1977. 1:250000 Geological Series – Explanatory Notes. *Crossland* Western Australia Sheet SE/51-16 International Index. Aust. Gov't Publ. Service, Canberra. 19 pp.

TOWNER, R. R., 1981. 1:250000 Geological Series – Explanatory Notes. *Derby* (Second Edition) Western Australia Sheet SE/51-7, International Index. Aust. Gov't. Publ. Service, Canberra. 38 pp.

YANG, S-P. & ZHANG, K.-F., 1982. Lower Permian animal fossils from Mount Ding Re Su Re, Tibet. In *Monograph on Mount Xixia Bangma Scientific Expedition*, Science Press, Beijing, pp. 310-315.

YEATES, A. N., CROWE, R. W. A., PASSMORE, V. L., TOWNER, R. R. & WYBORN, L. I. A., 1975. New and revised stratigraphic nomenclature, northeast Canning Basin. *Annu. Rep. Geol. Surv. W. Aust.* 1974: 49-51.